3.0 WATER QUALITY PROBLEMS, CAUSES & SOURCES

As part of the watershed planning process, an inventory and assessment of the watershed and existing water quality studies relevant to the watershed was conducted. Examination of previous work showed that data already gathered is sufficient for determining the magnitude and extent of water quality conditions, or may indicate that additional studies are needed to characterize the water quality problems. Once analysis of these studies was completed, water quality problems and links to pollution sources in the watershed could be determined. The following section provides a summary of water quality assessments, identifies pollutants of concern, links pollutants with potential sources, estimates existing pollutant loads, and concludes by establishing problem statements for the Lower Fall Creek Watershed.

3.1 STAKEHOLDER CONCERNS

Individuals living and working in the Lower Fall Creek Watershed have proven to have a wealth of knowledge as it relates to water quality, water quantity, and other natural resource issues in the watershed. Listed in **Table 3-1** are water quality issues of concern that were identified by Lower Fall Creek Watershed stakeholders.

Table 3-1: Stakeholder Concerns

Pollutant	Concern
Sediment	Lack of erosion control on construction sites
	Streambank erosion (lack of buffers)
	Tillage practices
Nutrients	Commercial and residential fertilizer application
	Inadequately functioning septic systems
	Combined Sewer Overflow's
Pathogens	Inadequately functioning septic systems
	Illicit storm sewer connections
	Waterfowl near waterways and retention ponds (Wildlife)
	Stormwater Runoff
	Combined Sewer Overflow's
	Livestock and Manure Management
	Indiana State Fairgrounds
Other	Invasive species
	Herbicide and pesticide applications
	Localized drainage and flooding problems
	Growth and Development
	Groundwater/Drinking Water Sources

3.2 WATER QUALITY BASELINE STUDIES

In addition to stakeholder input, a wide variety of water quality information was evaluated in order to ensure that the planning process considered the best available water quality information relevant to the Lower Fall Creek Watershed. Within this section, a summary of baseline water quality studies completed within the Lower Fall Creek Watershed is provided. In order to better compare water quality data, a suite of parameters and parameter benchmarks were identified to conduct water quality evaluations. **Table 3-2** identifies the water quality parameters and benchmarks that were chosen for the Lower Fall Creek Watershed. In many cases, water quality data is presented by 14-digit subwatershed (**Figure 3-1**).

Table 3-2: Water Quality Benchmarks

Parameter	Benchmark	Source
Dissolved Oxygen (DO)	4.0 mg/L	State Water Quality Standard
E. coli	125 CFU/100ml (5-week Geometric Mean) or 235 CFU/100ml (single grab sample)	State Water Quality Standard
Fecal coliform	200 colonies/100ml	EPA Recommendation
Nitrogen	10 mg/L	Indiana TMDL Guideline
Total Phosphorus	0.076 mg/L	EPA Recommendation
Atrazine	3.0 ppb	Drinking Water Standard
TSS	80 mg/L	IDEM Correspondence
Turbidity	10.4 NTU	EPA Recommendation

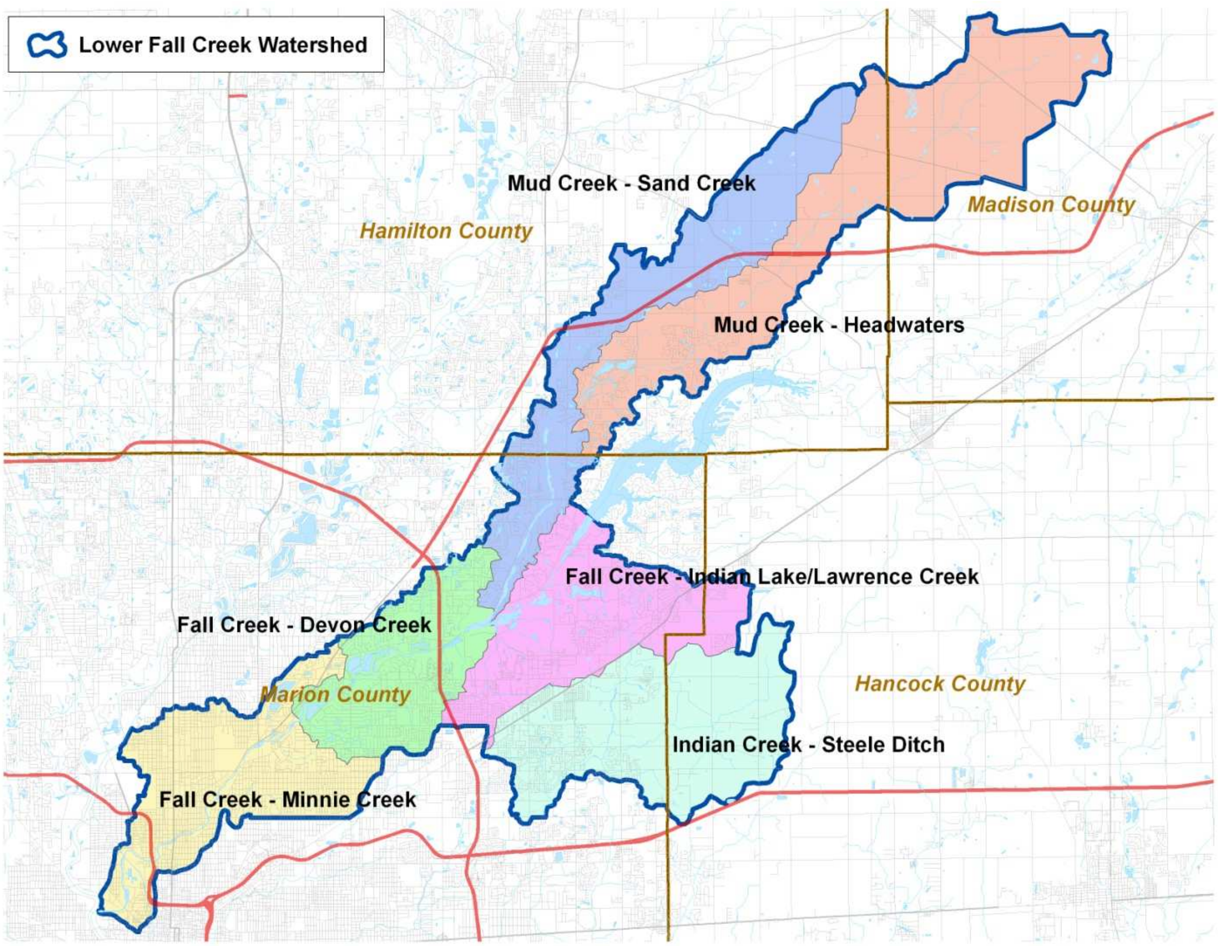

Figure 3-1: 14-digit Subwatersheds

Integrated Water Monitoring and Assessment

The Indiana Department of Environmental Management (IDEM) is the primary agency involved in surface water quality monitoring and assessment in the State of Indiana. In conjunction with the requirements of the Clean Water Act and the State's goals for protecting its natural and recreational resources, the IDEM operates several monitoring programs designed to monitor and assess the chemical, physical, and biological conditions of Indiana's rivers, streams, and lakes.

The IDEM's Office of Water Quality's Integrated Water Monitoring and Assessment strategy is designed to describe the overall environmental quality of each major river basin in the state and to identify monitored water bodies that do not fully support designated uses. All IDEM water quality data is evaluated by IDEM's 305(b) Coordinator and interpreted for each 14-digit HUC subwatershed. Each subwatershed is given a water quality rating relative to its streams status in meeting Indiana's Water Quality Standards (WQS). WQS are set at levels necessary for protecting a waterway's designated uses, such as swimmable, fishable, or drinkable. Each subwatershed is given a rating of its designated uses. **Table 3-3** below identifies known impairments of the Lower Fall Creek Watershed according to the 2008 Integrated Water Monitoring Assessment report.

Table 3-3: 2008 305(b) Report

Waterbody Name	Impairment
Fall Creek - Lawrence Creek (05120201110020)	PCBs in fish tissue
Fall Creek - Devon Creek (05120201110050)	PCBs in fish tissue
Fall Creek - Minnie Creek (05120201110060)	*E. coli* Mercury in fish tissue PCBs in fish tissue

(IDEM, 2006)

Based on the Integrated Water Monitoring and Assessment Report the following conclusions have been drawn:

- The *E. coli* water quality standard is consistently exceeded along Fall Creek in the Fall Creek – Minnie Creek Subwatershed.
- PCBs and Mercury concentrations are elevated along Fall Creek from the Geist Reservoir Spillway to the confluence of the White River.
- Lead levels are elevated along Fall Creek in the Fall Creek - Minnie Creek Subwatershed.

2008 303(d) List of Impaired Waters

Chapter 303(d) of the Clean Water Act requires states to identify waters that do not or are not expected to meet applicable water quality standards. States are also required to develop a priority ranking for these waters, taking into account the severity of the pollution and the designated use of the waters. Once this listing and ranking of waters is completed, States are required to develop Total Maximum Daily Loads (TMDL) for these waters in order to achieve water quality standards. As shown in **Table 3-4,** 5 waterbodies within the Lower Fall Creek Watershed are listed on the 2008 303(d) List of Impaired Waters.

Table 3-4: 2008 303(d) Impaired Waters

Waterbody Name	Impairments
Fall Creek	PCBs
Minnie Creek Tributaries	*E. coli,* Mercury, PCBs
Devon Creek	PCBs

(IDEM, 2008)

Based on the List of Impaired Waters the following conclusions have been drawn:
- The *E. coli* water quality standard is consistently exceeded along Fall Creek from the Geist Reservoir Spillway to the confluence of the White River.
- PCB and Mercury levels are elevated from the Geist Reservoir Spillway to the confluence of White River.

Fish Consumption Advisory (FCA)

Each year since 1972, three agencies have collaborated to create the Indiana Fish Consumption Advisory. These agencies include the Indiana Department of Environmental Management (IDEM), the Indiana Department of Natural Resources (IDNR), and the Indiana State Board of Health (ISBH). Each year, members from these agencies meet to discuss the findings of recent fish monitoring data and to develop the statewide fish consumption advisory.

The 2006 advisory is based on levels of PCBs and Mercury found in fish tissue. In each area, samples were taken of bottom-feeding fish, mid-water column feeding fish, and top-feeding fish. Fish tissue samples were analyzed for polychlorinated biphenyls (PCBs), pesticides, and heavy metals. Of those samples, the majority contained at least some Mercury. However, not all fish tissue samples had Mercury at levels considered harmful to human health. **Table 3-5** shows the fish consumption advisories within the Lower Fall Creek Watershed. A Level 3 advisory recommends limiting consumption to one meal per month (12 meals per year) for adults. Women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15 are under a zero consumption advisory. A Level 4 advisory limits consumption to one meal every 2 months (6 meals per year) for adults. Women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15 are under a zero consumption advisory. A Level 5 advisory is a zero consumption advisory (Do Not Eat).

Table 3-5: Fish Consumption Advisories

Waterway	Fish Species	Fish Size	Advisory
Fall Creek	Carp	<20 inches	3
		>20 inches	5
	Channel Catfish	<18 inches	3
		18 -20 inches	4
		>20 inches	5
	Large Mouth Bass	14 + inches	3

(ISDH, 2007)

Based on the Fish Consumption Advisory the following conclusions have been drawn:
- Fall Creek is under a fish consumption advisory from the Geist Reservoir Spillway to the confluence with the White River.

Fall Creek TMDL Study

Water quality data has been collected from Fall Creek by numerous state and local entities since 1991. In 1998, the IDEM determined that segments of Fall Creek do not consistently comply with the state's water quality standards for *E. coli* bacteria. As a result, segments of Fall Creek were listed on the 1998 303(d) list and required to have a TMDL evaluation for *E. coli* bacteria. This study was prepared for the City of Indianapolis and for IDEM pursuant to a contract with the State of Indiana. Data collected by several agencies was obtained for the water quality model development. For analysis purposes, Fall Creek was divided into segments. One segment consisted of areas up-stream of all of Indianapolis' Combined Sewer Overflow (CSO) outfalls, and another segment consisted of areas downstream of the most upstream CSO outfall. Fall Creek downstream of Keystone Avenue to the confluence with the White River is the stretch of river considered to be in the CSO area. CSO locations are indicated on **Exhibit 4-3**.

Based on the Fall Creek TMDL the following conclusions have been drawn:

- The *E. coli* water quality standard is consistently exceeded along Fall Creek from the Geist Reservoir Spillway to the confluence of the White River.
- A 52% reduction of *E. coli* loadings is needed upstream of the CSO area in order to meet water quality standards.
- A 99.5% reduction of *E. coli* bacteria loadings is needed in the CSO area in order to meet water quality standard.

Stream Reach Characterization and Evaluation Report

In 2002, the City of Indianapolis completed a Stream Reach Characterization Evaluation Report (SRCER) as a component of the CSO Long Term Control Plan. The purpose of the SRCER was to enable the City to undergo technically sound CSO planning by providing baseline water quality information within the City of Indianapolis.

Based on the SRCER the following conclusions have been drawn;

- Dissolved Oxygen (DO) levels are depressed within the Fall Creek Watershed.
- The *E. coli* water quality standard is consistently exceeded along Fall Creek from the Geist Reservoir Spillway to the confluence of the White River.
- Biological communities are impaired along Fall Creek from the Geist Reservoir Spillway to the confluence of the White River.

NPDES Permitted Facilities

Wastewater point source discharges include municipal (city, town, or county) and industrial wastewater treatment plants and small domestic wastewater treatment systems that may serve schools, commercial offices, residential subdivisions, and individual homes. Stormwater point source discharges include stormwater discharges associated with industrial activities and stormwater discharges from municipal separate storm sewer systems (MS4) operated by municipalities and counties.

Industrial point source dischargers in Indiana must apply for and obtain a National Pollutant Discharge Elimination System (NPDES) permit from the state. Discharge permits are issued under the NPDES program, which is delegated to DIEM by the US EPA. Within the boundaries of the Lower Fall Creek Watershed, there are 6 active NPDES permitted facilities. These facilities are:

- Indianapolis Water Company – White River
- Indianapolis Water Company – Fall Creek

- Mount Comfort Elementary School
- Peerless Pump
- Indianapolis Water Company – Geist Station
- IH Sewer Corporation (Exit 10)

Department of Public Works – Office of Environmental Services

The City of Indianapolis, Department of Public Works - Office of Environmental Services (DPW) has 3 primary surface water quality monitoring programs relevant to the Lower Fall Creek Watershed. The water quality monitoring programs are primarily used to monitor the success of the City's Stormwater Management and CSO strategies as they are implemented in accordance with State and Federal guidelines. However, this data is very broad based and is relevant and valuable to the Lower Fall Creek Watershed planning process.

DPW's Monthly White River Monitoring Program was implemented in January of 1991 to monitor the ambient quality of surface water passing through Marion County on a long-term basis, specifically in the West Fork of the White River and its tributaries. Currently, DPW is collecting water quality samples at 3 locations within the Lower Fall Creek Watershed as a component of their Monthly White River Monitoring Program: Fall Creek at 16th Street in the Fall Creek - Minnie Creek Subwatershed, Fall Creek at 71st Street in the Fall Creek – Devon Creek Subwatershed, and Fall Creek and Emerson Way in the Fall Creek – Lawrence Creek Subwatershed.

Based on monthly White River sampling data the following conclusions have been drawn:

- The *E. coli* water quality standard is consistently exceeded along Fall Creek from the Geist Reservoir Spillway to the confluence of the White River.
- Mean phosphorus concentrations along Fall Creek between Emerson Way and 16th Street are above EPA recommended thresholds.
- Mean nitrogen concentrations are below Indiana TMDL guidelines.
- Mean Total Suspended Solid (TSS) levels are typically below IDEM recommended thresholds.

DPW also conducts a continuous DO monitoring program, which monitors DO concentrations at strategic locations that have the potential for water quality impairment. Monitoring is typically conducted from mid-April/early-May through December. Continuous DO monitoring provides DPW the ability to observe diurnal and long-term patterns of DO changes at specific sites. Currently, Fall Creek at 16th Street in the Fall Creek-Minnie Creek Subwatershed is the only active site within the Lower Fall Creek Watershed

Based on Continuous DO sampling data the following conclusions have been drawn:

- Depressed DO levels and diurnal fluctuations are a concern in the Fall Creek- Minnie Creek Subwatershed.

Marion County Health Department (MCHD)

Historically, Marion County has conducted 4 Water Quality Sampling Programs throughout Marion County, an Ambient Water Quality Program, an Herbicides Program, a Public Access/Recreation Sampling Program, and a Macroinvertebrate Sampling Program.

In January of 1997, MCHD started an ambient sampling project for Fall Creek. This project consisted of 9 sites sampled 5 times per month, with geometric means calculated for each site's *E. coli* data. The purpose of the project was to find non-CSO influences of *E. coli* to Fall Creek. In 1999, the sampling points were adjusted to coincide with the City's CSO projects to help determine their overall impact to water quality, as well as to maintain data for historical comparison and continue working on non-CSO influences.

Presently, 6 sites on Fall Creek are sampled 5 times per month as a component of the ambient program, with geometric means calculated for each site's *E. coli* data. Active ambient sampling sites on Fall Creek are located on Fall Creek at Stadium Drive, Martin Luther King Jr. Street, Illinois Street, Central Avenue, 30th Street, and 39th Street in the Fall Creek–Minnie Creek Subwatershed.

Based on the ambient sampling data the following conclusions have been drawn:

- The *E. coli* water quality standard is consistently violated along Fall Creek within the Fall Creek - Minnie Creek Subwatershed.
- Phosphorus concentrations have typically been below detection limits of laboratory equipment utilized to analyze water quality samples. However, because the EPA recommended phosphorus threshold is lower than laboratory detection limits it is assumed that mean concentrations of phosphorus are at the existing detection limit of 0.19mg/L.
- Mean nitrogen concentrations are below Indiana TMDL guidelines.

In 1995, MCHD started an herbicide monitoring program for Eagle Creek, Fall Creek and White River to evaluate the level of herbicides in Marion County source water. Historically, samples have been collected at 7 sites in the Lower Fall Creek Watershed. Those sites consist of Fall Creek at 79th Street, Indian Creek at Indian Creek Road, Lawrence Creek at Shatner Rd, and Fall Creek at Emerson Way in the Fall Creek - Lawrence Creek Subwatershed, Mud Creek at Fall Creek Road in the Mud Creek - Sand Creek Subwatershed, and Fall Creek at Keystone Avenue in the Fall Creek - Minnie Creek Subwatershed. Currently, samples are only collected from Fall Creek at the Keystone Avenue site.

Based on the Herbicide sampling data the following conclusions have been drawn:

- Mean atrazine levels at Fall Creek and Keystone are above the state water quality standard.
- Phosphorus concentrations have typically been below detection limits of laboratory equipment utilized to analyze water quality samples. However, because the EPA recommended phosphorus threshold is lower than laboratory detection limits it is assumed that mean concentrations of phosphorus are at the existing detection limit of 0.19mg/L.
- Mean nitrogen levels are below Indiana TMDL guidelines.

For many years, the MCHD has collected monthly grab samples for *E. coli* from the major waterways in Marion County during the recreational season (April through October). The purpose of the Recreational sampling program, is to warn people of potentially elevated *E. coli* levels in areas frequented for recreation. Such places are in/or near parks, greenways, canoe launches, schools, and fishing areas. Currently the Health Department is not conducting any public recreation monitoring within the Lower Fall Creek Watershed.

Based on historic recreational season sampling data the following conclusions have been drawn:

- The *E. coli* water quality standard is consistently exceeded along Fall Creek and its tributaries.

In 1998, MCHD completed its first annual collection of benthic macroinvertebrates from streams throughout Marion County. There are many advantages of using benthic macroinvertebrates to assess the quality of a stream. First, monitoring of biological communities is relatively inexpensive in comparison to the cost of assessing chemical or bacterial parameters. It also has minimal detrimental effects on the resident biota. Benthic macroinvertebrates are also good indicators of localized conditions, as many of the animals have limited migration patterns. Sensitive life stages respond quickly to stress while the overall community will respond more slowly. Within the Lower Fall Creek Watershed, the MCHD is actively collecting macroinvertebrate samples on Fall Creek at 16th Street, Central Avenue, and 39th Street in the Fall Creek - Minnie Creek Subwatershed, Emerson Way in the Fall Creek-Devon Creek Subwatershed, and at 79th Street in the Fall Creek – Lawrence Creek Subwatershed.

Based on MCHD macroinvertebrate data the following conclusions have been drawn:

- Biological communities in Fall Creek at Emerson Way are considered to be good under the Hilsenhoff Biological Index (HBI). A score of good is indicative of some organic pollution.
- Biological communities in Fall Creek at 39th Street are considered to be good under the HBI.
- Biological communities in Fall Creek at 79th Street are considered fairly poor under the HBI. A score of fairly poor is indicative of significant organic pollution.
- Biological communities in Fall Creek at Central Avenue are considered fairly poor under the HBI.
- Biological communities in Fall Creek at 16th Street are considered poor under the HBI. A score of poor is indicative of very significant organic pollution.

Mud Creek Bioassessment 2003

During May, June, and October 2003, students from Indiana University Southeast used rapid bioassessment protocols to assess the status of Mud Creek. In particular, the study looked at eight sites located within the Mud Creek Headwaters Subwatershed and the Mud Creek - Sand Creek Subwatershed. Three of those sites, Mud Creek at Atlantic Road, Mud Creek at Olio Road, and Mud Creek at Brook School Avenue, were located in the Mud Creek Headwaters Subwatershed; and five of those sites, Sand Creek near Verizon Wireless Entertainment Complex, Sand Creek at Mud Creek near 106th Street, Mud Creek at 106th Street, Mud Creek at Cumberland Road, and Mud Creek at 96th Street were located in the Mud Creek - Sand Creek Subwatershed.

Based on the Mud Creek Bioassessment the following conclusions have been drawn:

- *Fecal coli form* concentrations in Mud Creek and Sand Creek are exceeding EPA recommended thresholds.
- Phosphorus concentrations in Mud Creek and Sand Creek are exceeding EPA recommended thresholds.
- Nitrogen concentrations in Mud Creek and Sand Creek are below Indiana TMDL guidelines.
- Turbidity levels (NTU) in Mud Creek and Sand Creek are exceeding EPA recommended reference conditions.
- Macroinvertebrate communities in Mud Creek and Sand Creek are classified as slightly impaired.
- Habitat in Mud Creek and Sand Creek is classified as slightly impaired.

1991 – 2005 Fixed Station Water Quality Results

Under IDEM's Fixed Station Water Quality Monitoring Program, IDEM scientists collect water samples and field analytical data every month from 160 sampling sites at selected rivers, streams, and lakes throughout the state. This program has been collecting water quality samples from two sites within the Lower Fall Creek Watershed since February of 1991. The first site is located on Fall Creek at Keystone Avenue in the Fall Creek - Minnie Creek Subwatershed; the second site is also located on Fall Creek in the Fall Creek - Minnie Creek Subwatershed, but further downstream at Stadium Drive.

Based on Fixed Station sampling data, the following conclusions have been drawn:

- The *E. coli* water quality standard is consistently exceeded along Fall Creek from the Geist Reservoir Spillway to the confluence of the White River.
- Mean phosphorus concentrations on Fall Creek at Stadium Drive area above EPA recommended thresholds.
- Mean nitrogen concentrations are below Indiana TMDL guidelines.
- Mean Total Suspended Solid (TSS) levels are typically below IDEM recommended thresholds.

Lower Fall Creek IUPUI Assessment 2007

In October of 2007 two IUPUI students completed Citizen Qualitative Habitat Evaluation Index (CQHEI) assessment sheets at 16 specified locations (**Figure 3-2**) within the upper reaches of the Lower Fall Creek Watershed.

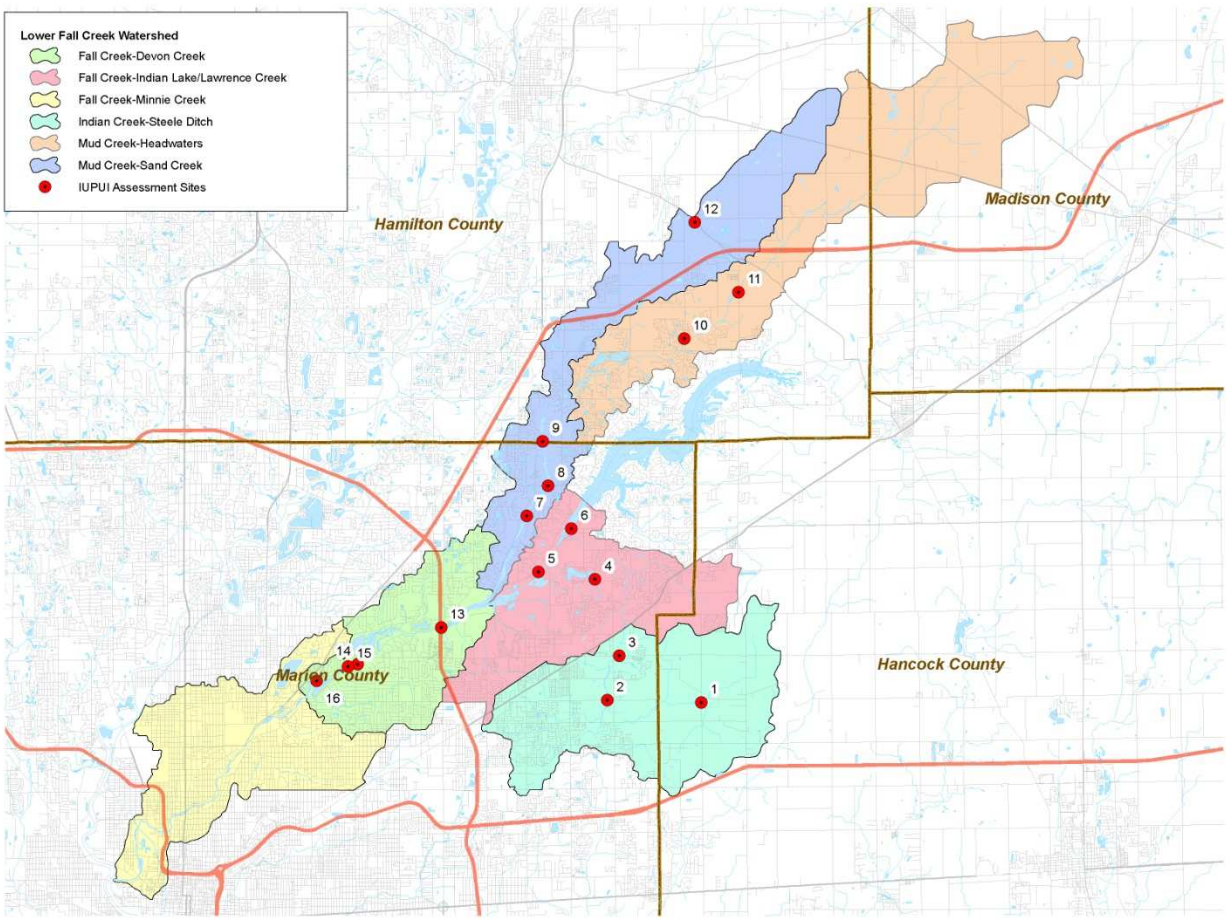

Figure 3-2: IUPUI Assessment Sites

The CQHEI was developed by the Ohio EPA to provide a measure of the stream habitat and riparian health that generally corresponds to physical factors affecting fish and other aquatic life. The CQHEI produces a total score, with a maximum of 114, which can be utilized to compare changes at one site over time or to compare 2 different sites. Further, Ohio EPA has determined that "CQHEI scores > 60 have been found to be generally conducive to the existence of warmwater fauna".

Parameter sections are given an individual score and the total of those sections is the overall site score.

Parameters that are evaluated include:

- Substrate (bottom type)
- Fish Cover (hiding places)
- Stream Shape and Human Alterations
- Stream Forests & Wetlands (Riparian Area) & Erosion
- Depth and Velocity
- Riffles/Runs (areas where current is fast/turbulent, surface may be broken)

Based on CQHEI data the following conclusions have been drawn:

- Of 16 sites, 9 received scores >60 in part due to high scoring Substrate and Stream Forests & Wetlands sections.
- Of those 9 sites receiving > 60, 4 sites received scores >80 and all were along the main stem of Fall Creek.
- Sites 12 and 1, both in the upper reaches of the watershed, received the lower scores of 20 and 34 respectively. Both CQHEI scores indicate a very fine (silt) substrate, stream alterations, and no riffle/run sequences.
- CQHEI scores seemed to generally increase from upstream to downstream throughout the watershed.

<u>Lower Fall Creek Commonwealth Biomonitoring Assessment 2008</u>

As a part of the Lower Fall Creek WMP development, macro-invertebrate sampling and geomorphic assessments were completed by Commonwealth Biomonitoring, Inc. While there have been several studies measuring the chemical water quality throughout the watershed, there is very little data related to the biological water quality. The objectives of this bioassessment were to characterize the biological and physical integrity of Lower Fall Creek and its tributaries and to make recommendations to solve any identified problems. This was accomplished by utilizing the Index of Biotic Integrity (IBI) and the Qualitative Habitat Evaluation Index (QHEI) at 12 sites in the watershed. In addition, Rapid Stream Assessments were completed measuring river corridor encroachments, bank measurements, sinuosity, and bed substrate. **Figure 3-3** identifies the macroinvertebrate sampling locations.

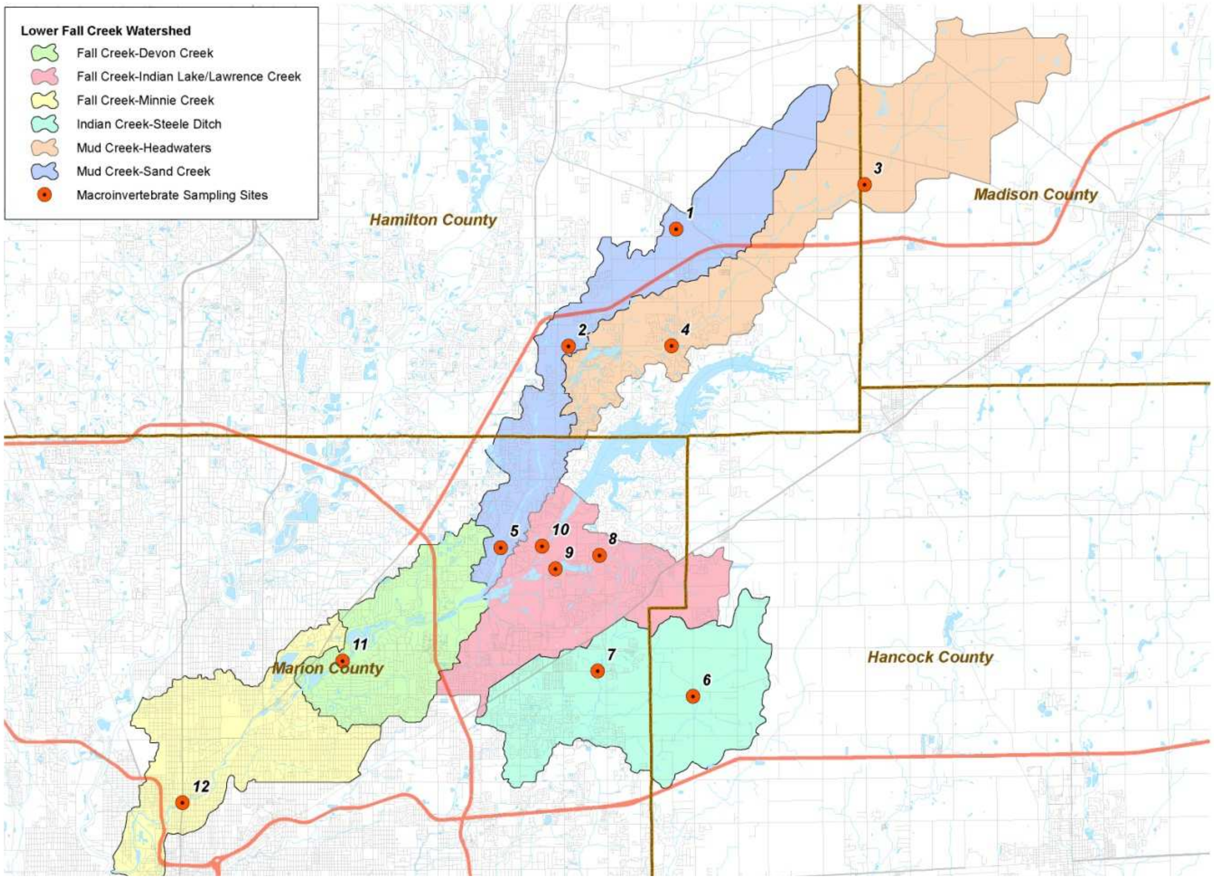

Figure 3-3: Macroinvertebrate Sampling Sites

Based on the findings of the Commonwealth Biomonitoring assessment, the following conclusions have been drawn:

- Heavy silt deposits were observed at all sites within the Indian Creek subwatershed.
- Habitat quality was limited by a lack of in-stream cover and riparian vegetation in the Fall Creek subwatershed.
- While habitat quality at the sites within the Mud Creek subwatershed were reduced by past channelization, it was overall good.
- Sand Creek subwatershed sites had the poorest habitat scores due to heavy silt deposits, unstable substrates, and evidence of recent channelization.

Commonwealth Biomonitoring also provided 4 recommendations as to enhance the overall water quality and macroinvertebrate assemblages within the Lower Fall Creek Watershed. These include:

1. Control inflow of sediment and silt into streams with special emphasis placed on the Indian Lake subwatershed.
2. Investigate status of water quality within Geist Reservoir as it may be impairing biotic integrity downstream in Fall Creek.
3. Enhance habitat by planting riparian vegetation especially upstream of site 6 and downstream of site 12.
4. Avoid future channelization of streams.

A report provided by Commonwealth Biomonitoring, as well as the data collected through the assessment, is located in **Appendix 7.**

Summary of Water Quality Conclusions

Based on the analysis of water quality studies and data, the following quality conclusions have been drawn:

- Bacteria concentrations exceed EPA recommended thresholds and Water Quality Standards throughout the Lower Fall Creek Watershed.
- Phosphorus levels are exceeding EPA recommended thresholds throughout the Lower Fall Creek Watershed.
- Depressed DO levels and diurnal fluctuations are a concern in the Fall Creek- Minnie Creek Subwatershed.
- Biological communities are stressed throughout the Lower Fall Creek Watershed.
- Habitat is degraded within the Mud Creek - Sand Creek and Mud Creek Headwaters Subwatersheds.
- Atrazine concentrations are exceeding the State Water Quality Standard in the Fall Creek – Minnie Creek Subwatershed.
- PCB and Mercury levels are elevated throughout the Lower Fall Creek Watershed.

For the purposes of this planning effort, the focus of the WMP will be placed on reducing sediment, nutrient, and pathogen loadings to the Lower Fall Creek Watershed. These 3 main pollutants were discussed and agreed upon by the Steering Committee and the 3 Working Groups. While TSS levels were typically below IDEM recommended thresholds, the Steering Committee and Working Groups felt that this issue was prevalent throughout the watershed and warranted focus in the WMP.

It was discussed that insufficient data and studies have been collected and completed regarding invasive species, herbicide and pesticide applications and associated water quality problems, as well as localized drainage and flooding problems. While it is known that these issues exist and impact water quality, there is currently not enough data to support water quality conclusions regarding the Lower Fall Creek Watershed.

While the baseline studies mentioned above do not specifically indicate water quality problems associated with sedimentation or elevated levels of TSS, several stakeholders have brought this issue to the discussion. Erosion and sedimentation especially as it relates to streambank destabilization and stormwater runoff were discussed and will therefore be included in this WMP.

It can be anticipated that some of the water quality impacts associated with depressed DO levels, stressed biological communities, and habitat degradation will also be reduced through the potential management measures identified in **Section 5.0** for the purpose of addressing sediment, nutrient, and pathogen loadings. Further, it was determined that while it is important to identify areas affected by, and the water quality impacts associated with, increased Atrazine, PCBs, Lead, and Mercury levels, it is not feasible for the WMP to address these issues. Much of the work associated with Atrazine, PCBs, Lead, and Mercury contamination in streams and rivers needs to be addressed and remediated at the State and Federal levels. In addition, much of the CSO issues and associated *E. coli* loadings will be addressed during the implementation of the City of Indianapolis' LTCP.

3.3 CAUSES AND SOURCES OF POLLUTION

For each pollutant to be addressed within this WMP (sediment, nutrients, and pathogens), potential sources of that pollutant within the Lower Fall Creek Watershed will be discussed in further detail. The Land Use & Economic Development Work Group, in working to create the land use categories for Lower Fall Creek, also developed **Table 3-6** Land Use Categories and Associated Pollutants. This table is designed to highlight land use categories and potential sources of pollutants that are associated with those land use categories.

Table 3-6: Land Use Categories and Associated Pollutants

Land Use Category	Associated Pollutant
1. **Agriculture**	Sediment – tillage practices, streambank erosion from encroachment Nutrients – fertilizer application, livestock and manure management Pathogens – failing septic systems, livestock, wildlife, and manure management
2. **Low-Density Residential**	Sediment – streambank erosion from encroachment and stormwater runoff Nutrients – fertilizer application and failing septic systems Pathogens – failing septic systems, stormwater runoff, domestic pet and wildlife waste
3. **Commercial, Industrial, Educational, Medium-to-High Residential** (without NPDES permit)	Sediment – streambank erosion from encroachment and stormwater runoff Nutrients – fertilizer application, combined sewer overflows Pathogens – stormwater runoff, domestic pet and wildlife waste, combined sewer overflows, illicit stormwater connections
4. Commercial, Industrial (with NPDES permit)	Sediment – streambank erosion from encroachment and stormwater runoff Nutrients – combined sewer overflows Pathogens – stormwater runoff, combined sewer overflows, illicit stormwater connections
5. **Open Space**	Sediment – streambank erosion from encroachment and stormwater runoff Nutrients – fertilizer application Pathogens – stormwater runoff, domestic pet and wildlife waste
6. **Golf Course**	Sediment – streambank erosion from encroachment and stormwater runoff Nutrients – fertilizer application Pathogens – stormwater runoff, wildlife waste
7. **Active Construction**	Sediment – failing erosion and sediment control practices

Sediment

By volume, sediment is the greatest pollutant entering our nation's surface waters. Erosion and sedimentation occur when wind or water runoff carries soil particles from an area, such as a farm field, stream bank, or construction site and transports them to a water body. Within Lower Fall Creek Watershed, sediment loads are anticipated to originate from conventional tillage practices where loosened soils remain exposed to weather, streambank erosion exacerbated by encroachment of activities such as tillage or development, and failing sediment and erosion control practices on active construction sites.

Like nutrients, sediment also impacts fisheries, drinking water supplies, and recreational uses of waterways. By reducing the amount of sunlight reaching aquatic plants, the availability of fish cover and food is greatly reduced, and mating practices are impacted. Sediment also impacts fish communities by covering and filling fish spawning areas and smothering benthic food supplies. Sediment loads also tend to increase drinking water treatment costs and can result in damage to pumps and other water treatment equipment. Finally, sediments impact recreational uses by reducing water clarity, aesthetic value, and sport fishing populations. There are three primary sources of sediment within the Lower Fall Creek Watershed, tillage practices, construction and development, and stream bank erosion.

Tillage Practices

One way to minimize sedimentation and erosion associated with agricultural activities is to implement conservation tillage practices. No-till refers to any direct seeding system, including strip preparation, with minimal soil disturbance. Mulch till refers to any tillage system leaving greater than 30% crop residue cover after planting, excluding no-till. No-till and mulch till are often grouped together into conservation tillage. **Table 3-7** compares various tillage methods utilized within the Lower Fall Creek Watershed.

During various water quality sampling and habitat assessment events it has been noted that turbidity and siltation levels are increased in areas where conventional tillage practices still occur. An increase in conservation tillage practices in the Lower Fall Creek Watershed will likely reduce the loading of fine clay particulates and surface erosion materials that are delivered to adjacent waterways. Water quality impacts associated with conventional tillage practices can be exacerbated when they occur on highly erodible lands (HEL). If not managed properly, HELs can erode at accelerated rates and may lead to excessive soil deposition in waterways. HELs are determined based on slope and other erodibility factors. According to the USDA, the soil of an entire crop field is considered erodible if at least one-third of the field has highly erodible soils. There are approximately 13,500 acres of highly erodible soils within the Lower Fall Creek Watershed (**Exhibit 4-1**). HELs are primarily a concern for erosion associated with agricultural practices.

Table 3-7: Percent of Crop Acres in Conservation Tillage

County	Crop	% No Till (2004)	% Mulch-Till	% Conventional Till	State Rank
Hamilton	Corn	25%	5%	61%	36 of 92 Counties
	Soybeans	74%	74%	8%	21 of 92 Counties
Hancock	Corn	2%	3%	70%	89 of 92 Counties
	Soybeans	47%	22%	10%	73 of 92 Counties
Madison	Corn	11%	2%	81%	63 of 92 Counties
	Soybeans	68%	5%	16%	31 of 92 Counties
Marion	Corn	*No Data*	*No Data*	*No Data*	*No Data*
	Soybeans	*No Data*	*No Data*	*No Data*	*No Data*

(ISDA, 2004)

It is also noted that within the middle reaches of the watershed (Hamilton County), rapid growth and development is converting agricultural lands to other land uses, such as residential and commercial. As this rate of development is one of the highest in Indiana, it is anticipated that agricultural land, and specifically tillage practices, will be of little concern in the near future. In the Madison County portions of the watershed, agriculture remains the primary land use. While growth and development are not occurring as rapidly as in Hamilton County, it is anticipated that eventually this area, especially as the Interstate 69 corridor is developed, will be converted from agricultural land use to commercial, industrial or residential land use. Throughout this time of land use conversion, efforts to reduce the erosion occurring from conventional tillage practices and HELs on agricultural lands will best be led by the individual county SWCDs by utilizing existing federal funding sources through USDA.

Construction and Development Practices

Construction and development practices can also result in excessive sediment loading to local waterways. As stormwater flows over a construction site, it picks up pollutants like sediment, debris, and other pollutants associated with land-disturbing activities. As was the case with tillage practices, when land disturbing activities occur on HELs, sediment loads to local waterways have the potential to increase substantially. Exhibit 4-1 identifies areas of known and potentially HEL classified soils. Exhibit 4-1 paired with Exhibit 2-2 can be used to further highlight areas where growth and development is being planned and where HEL or PHEL classified soils exist, especially in the Mud Creek and Sand Creek subwatersheds.

The NPDES Stormwater Phase I and Phase II programs require operators of construction sites greater than or equal to 1 acre (including smaller sites that are part of a larger common plan of development) to obtain authorization to discharge stormwater under an NPDES construction stormwater permit. Within the Lower Fall Creek Watershed there are several local and state agencies responsible for ensuring local compliance with stormwater requirements. Included among the agencies are the Hamilton, Hancock, Madison, and Marion County SWCDs, the City of Indianapolis DPW, the Hamilton and Hancock County Surveyor's Office, the Fishers Department of Engineering and Public Works, the Noblesville Wastewater Department, the

Lawrence Department of Public Works, the McCordsville Town Engineer, and the IDEM. Despite the number of agencies charged with monitoring erosion and sediment control practices on construction and development sites within the watershed, enforcement efforts tend to be inconsistent, and program resources tend to be underfunded.

Efforts to reduce stormwater runoff and related erosion from construction and development within the Lower Fall Creek Watershed could greatly reduce the sediment loadings to Fall Creek and tributary streams. As continued urbanization and re-development occurs throughout the Lower Fall Creek watershed, practices such as Low Impact Development (LID) and proper erosion control practices during construction could result in a significant reduction in sediment loadings.

Streambank Erosion

Overall streambank erosion is a natural phenomenon. When a stream is healthy, it balances water flow, sediment loads, and its overall shape and energy. However, excessive erosion tends to pollute water supplies, smother aquatic habitat, and threaten property and infrastructure.

Surrounding land use activities have a tremendous impact on the rate at which streambank erosion occurs within a watershed. As development and impervious surface increase in a watershed, so to do stream flow volumes and peak discharges, which accelerate erosion. As impervious areas and developed acres increase, the amount of pervious surfaces and open space uses, such as riparian buffers tend to decrease in the watershed. Riparian buffers are one of the most beneficial types of open space in any watershed. These areas consist of large overstory trees, smaller woody shrubs, and herbaceous groundcover that act as natural barriers against stream bank erosion. However, as riparian vegetation is changed from woody species to annual grasses and/or forbs, which is often the case on development sites, the internal strength of the stream bank is weakened and erosion rates are increased.

Areas where little to no riparian vegetation exists, as in the primarily agricultural areas of Hancock and Madison County portions of the watershed, are considered to be areas of concern regarding sedimentation and potential streambank erosion. This concern is validated by the findings of the 2007 IUPUI Assessment and the 2008 Bio assessment. In both assessments, the sites associated with the most marked erosion are located in the upper reaches of the watershed; in Hamilton and Hancock Counties. Of notable significance is the Hancock County sampling site within the 2008 Bioassessment. At this site, no trees were present and clumps of streambank were slumping into the channel.

Significant streambank erosion problems in more urban areas, such as the Windridge Condominiums site discussed in Chapter 4 have been identified through stakeholder input and the IUPUI Assessment. Several residents and neighbors of Windridge Condominiums expressed deep concern over the magnitude of the erosion and failing of the streambank in that area. Further, the IUPUI assessment indicated undercut banks, downed trees, and a combination of stable and eroding banks in Marion County (sites #14, 15, and 16).

Estimated Existing Sediment Loads

In order to estimate existing sediment loadings, EPA's Spreadsheet Tool for Estimating Pollutant Loads (STEP-L) was utilized. STEP–L employs simple algorithms to calculate nutrient and sediment loads from different land uses and load reductions that would result from the implementation of various best management practices (BMPs). Based on STEP-L results, existing sediment loads within the Lower Fall Creek Watershed are estimated at 13,748 Tons/Year.

Efforts to reduce the sediment loads to the Lower Fall Creek Watershed focus on reducing the inputs from construction and development practices as well as streambank stabilization measures, both structural and non-structural. These are discussed further in **Section 5.0** of this WMP. Agricultural practices to reduce sediment loadings within the Lower Fall Creek watershed were considered but are not the focus of this planning effort. As urbanization and development occurs throughout the upper reaches of the watershed, agricultural sediment sources will be reduced. Due to the transitional nature of the watershed, the Steering Committee and Work Groups chose to focus on measures designed to prevent future loadings from developed lands.

Nutrients (Phosphorus and Nitrogen)

According to the EPA, nutrient pollution, especially from nitrogen and phosphorus, has consistently ranked as one of the top causes of degradation of waters of the US for more than a decade. Nutrients impact fisheries by promoting algal blooms that reduce plant growth and by reducing dissolved oxygen concentrations through increased productivity and decay of organic matter. Nutrients impact drinking water supplies by increasing treatment costs. Finally, nutrient concentrations, especially phosphorus, can limit recreational uses of waterways. Blue-Green algae, also known as cyanobacteria, which resulted in the use restrictions on Geist Reservoir in the summer of 2007, thrive in phosphorus rich waters. There are 3 primary sources of nutrients within the Lower Fall Creek Watershed, 1) fertilizer application, 2) inadequately functioning septic systems, and 3) combined sewer overflows. An additional source of nutrient loading is manure from agricultural and hobby operations in the more rural areas of the watershed. More detail on the agricultural impact will be provided later in this section as bacteria and pathogens are the primary pollutants of concern regarding manure.

Fertilizer Application

Nutrients such as phosphorus and nitrogen in the form of commercial fertilizers are often applied by agricultural users to enhance crop production. Similarly, residential and commercial property owners in the Lower Fall Creek Watershed routinely utilize fertilizers to promote the growth of turf grass and other landscaping.

The Office of Indiana State Chemist (OISC) annually publishes the total tonnages of commercial fertilizers sold in each Indiana County. The list includes single nutrient fertilizers, multi-nutrient fertilizers, as well as organic and micronutrient fertilizers. **Table 3-8** estimates the annual nutrient application based on the amount of nutrients sold in the Lower Fall Creek Watershed. Total countywide application rates were multiplied by the percent of the County’s land area within the Lower Fall Creek Watershed in order to estimate watershed wide application.

Table 3-8: Estimate of Nutrient Applications

County	% of County in Watershed	x	Total Nutrients (tons)		X 2,000 lbs/ton	Nutrients in watershed (lbs)	
			N	P2O5		N	P2O5
Hamilton	5.97%	x	1,425	1,079	X 2000	170278	128,934
Hancock	3.40%	x	307	764	X 2000	20,889	51,986
Madison	2.72%	x	641	1,327	X 2000	34,882	72,213
Marion	10.75%	x	410	549	X 2000	88,174	118,067
Total						314,224	371,199

(OISC, 2007)

The table shown above describes an estimate of the amount of fertilizer applied in the Lower Fall Creek Watershed and is not intended to serve as an estimate of loadings to waterways. Based upon nutrient removal rates from crops and turf grasses, it is expected that only a portion of the applied fertilizer nutrients would be mobilized to local waterways, as a majority of the macronutrient would be utilized by the vegetation to which it was applied.

Lawn and garden practices associated with residential and commercial land uses are expected to be a substantial source of the excess nutrients in the watershed as these land uses are the most prevalent. Much of the estimated nutrients applied within the Lower Fall Creek Watershed are within Hamilton and Marion Counties, as indicated in Table 3-7. As land uses transition within the watershed (as identified on Exhibit 2-2) the anticipation is that an increase in fertilizers and nutrients applied to residential and commercial lawns will increase accordingly. The Hamilton County portion, and eventually the Hancock and Madison County areas, would be the area expected to see the largest rise in applications of these additives.

Professional lawn and garden chemical applicators receive training and are required to maintain application records, but the average citizen does not. Therefore, the typical resident and business owner may often over-apply lawn and garden chemicals, which are easily washed away and contribute significant nutrient loads to adjacent waterbodies. Applications of fertilizers from either a professional or an individual home or business owner need to be completed according to the product's instructions, but also in accordance with the needs of the soil. Many times, even in cases where professional services are utilized, soil nutrient levels are not analyzed.

Additionally, yard wastes such as grass clippings, leaves, and dead plants are high in organic matter, and when piled or dumped on nearby stream banks, they can potentially smother naturally stabilizing vegetation. This smothering can lead to increased bank erosion and decreased levels of dissolved oxygen. The long-term effects of yard waste dumping is increased levels of nutrients from the decomposition of the waste, as well as the increased nutrient levels associated with increased sedimentation and destabilization of streambanks. Yard wastes are considered a source of pollution in the Lower Fall Creek Watershed, however the relative extent of that pollution is not known at this time.

Based on decisions made by the Steering Committee and Work Groups, the focus of efforts to reduce nutrient loadings from fertilizer application and yard wastes will be directed to golf courses and residential lakes over 50 acres in size. There are 8 golf courses within the Lower Fall Creek Watershed; 1 located in a WFPA and 5 additional courses that are located directly adjacent to or spanning tributary streams. These public golf courses are highly visible and could be utilized as a demonstration area for practices reducing the application and potential runoff of excess nutrients.

Lakes larger than 50 acres and surrounded by residential land use were also selected as a focus area. These lakes are directly connected to either surface or ground water resources in the Lower Fall Creek Watershed and transferred water may carry with it increased levels of nutrients from fertilizers applied to the residential lawns surrounding these lakes. Specific details regarding these areas are provided in Chapter 4 in this WMP.

Inadequately Functioning Septic Systems
Inadequately functioning septic systems are a large source of nutrients in the watershed. According to the EPA, even fully functional septic systems reduce only 28% of nitrogen concentration and 57% of phosphorus concentration of household wastewater. As septic systems fall into disrepair, these removal capabilities are reduced even further. According to the Chesapeake Bay Journal, a properly operating septic system is releasing more than ten pounds of nitrogen per year to groundwater for each person using it, and approximately 26% of that is making its way to open waters.

Within the Lower Fall Creek Watershed, the Marion County Health Department and the Indianapolis DPW have identified areas serviced by residential septic systems and prioritized these areas for connection to sanitary sewer through the Septic Tank Elimination Program (STEP). These areas are illustrated on **Exhibit 4-3**.

While nutrients from inadequately functioning septic systems is a concern within the Lower Fall Creek watershed, the primary pollutant from these sources is pathogens. Therefore, more detailed information regarding the magnitude of the concern, location of unsewered areas will be found in the pathogens portion of this section.

Combined Sewer Overflows (CSOs)
Like septic systems, CSOs are also a source of nutrients to waterways within the lower portions of the Lower Fall Creek Watershed. The CSO locations within the watershed have been identified on Exhibit 4-3. Implementation of the Indianapolis CSO LTCP will greatly reduce the loadings of nutrients to Fall Creek. As mentioned above, the LTCP established a schedule of detailed actions that will be taken to reduce water quality problems associated with CSOs, and should be referenced for all CSO-related water quality improvements.

Estimated Existing Nutrient (Phosphorus and Nitrogen) Loads
Based on STEP-L results, existing phosphorus loads within the Lower Fall Creek Watershed are estimated at 85,590 lbs/year, and existing nitrogen loads are estimated at 405,439 lbs/year.

Efforts to reduce the nutrient loads to the Lower Fall Creek Watershed focus on reducing the inputs from fertilizer application to golf courses and residential properties surrounding lakes greater than 50 acres. These are discussed further in Section 5.0 of this WMP.

Pathogens

Bacteria concentrations within the Lower Fall Creek watershed have typically been measured via *E. coli* or fecal coliform concentrations. The presence of fecal coliform bacteria in aquatic environments indicates that water has been contaminated with the fecal material of humans or other animals. Similarly, *E. coli* bacteria is associated with the intestinal track of warm blooded animals and is widely used as an indicator of sewage pollution in surface waters. Where bacteria concentrations are elevated there is an increased likelihood that disease causing organisms may be present in surface waters. Bacteria have detrimental effects on fisheries, water supply, and recreational uses of water bodies. Bacteriological contamination exposes aquatic life to disease causing organisms, increases drinking water treatment costs and threatens public health by threatening the drinking water supply, and prevents recreational uses of waterbodies.

As discussed above, the 2003 Fall Creek TMDL Study quantified and established pollutant reduction targets for *E. coli* in the Lower Fall Creek Watershed. According to the TMDL, the primary sources contributing the greatest loadings of bacteria to surface waters in the Lower Fall Creek Watershed are 1) inadequately functioning septic systems, 2) illicit connections to the storm sewer, 3) wildlife and background levels, 4) urban stormwater, and 5) CSOs.

Inadequately Functioning Septic Systems
Failing and inadequately functioning septic systems are common sources of bacteria in waterbodies throughout Indiana. While septic systems can be a safe and effective method for treating wastewater if they are sized, sited, and maintained properly, they frequently fall into disrepair. Unfortunately, homeowners are often unaware of how septic systems function, where their system is located, or how they should maintain their system.

Within the Lower Fall Creek Watershed 92% of soils are considered to be moderately or severely limited for onsite wastewater treatment. These soil limitations are identified on Exhibit 4-1. **Table 3-9** identifies subdivisions within the Lower Fall Creek Watershed that have been prioritized under the City of Indianapolis' Septic Tank Elimination Program (STEP). These areas are also identified in Exhibit 4-3.

Table 3-9: STEP Priorities

Project Name	Primary Subwatershed	Priority Ranking
42nd and Sherman	Fall Creek – Devon Creek	High
42nd and Millersville	Fall Creek – Minnie Creek	High
46th and Millersville	Fall Creek – Devon Creek	High
82nd and Red Bud	Mud Creek – Sand Creek	High
46th and Emerson	Fall Creek – Devon Creek	High
48th and Allisonville	Fall Creek – Minnie Creek	Medium
61st and Allisonville	Fall Creek – Minnie Creek	Medium
Fall Creek and Johnson	Fall Creek – Devon Creek	Low
55th and Allisonville	Fall Creek – Minnie Creek	Low
56th and Fall Creek	Fall Creek – Devon Creek	Low
57th and Kessler	Fall Creek – Minnie Creek	Low
46th and Ritter	Fall Creek – Devon Creek	Low

Problems with inadequate septic systems are intensified when those systems are located in floodplain areas. Flooding leads septic systems to function improperly which can result in stormwater runoff that contains elevated concentrations of *E. coli,* nutrients, and other pollutants. None of the STEP subdivisions lie within a regulated floodplain area.

In the Lower Fall Creek Watershed, Hamilton County, the Town of Fishers, and the City of Noblesville are serviced by Hamilton Southeastern Utilities. Information regarding the sewer service area of Hamilton Southeastern Utilities was unavailable. It is assumed that areas outside of these sanitary service areas are served by on-site septic systems. As the Town of

Fishers and City of Noblesville grow, areas on septic are required to connect to sanitary sewer. As growth and development are planned throughout Hamilton County, especially in the portion of the watershed north of 146th Street and east to the Hamilton – Madison County line, existing residential septic systems will be replaced with sanitary sewer service, potentially reducing the pathogen loadings to Sand and Mud Creeks. Portions of Sand and Mud Creek in this area have delineated floodplains where few residential properties currently exist.

Development in the Madison County portion of the Lower Fall Creek is scattered, very low density, and serviced by septic systems. None of the streams in the Madison County portion of the watershed have delineated floodplains. In Hancock County, with the exception of some isolated septic systems, the developed areas are serviced by the Town of McCordsville Sewer District.

Illicit Connections to the Storm Sewer

In addition to falling into disrepair, septic systems are often tied directly into local drainage tiles, ditches, and storm sewer systems. While this connection may have been intentional at one time, often times current homeowners or tenants are unaware that their wastewater is tied directly into these conveyances. According to research completed by the Center for Watershed Protection, some of the most common types of illicit connections include broken sanitary lines, cross connections, sanitary sewer overflows, and direct connections from septic systems.

As part of NPDES Stormwater Phase I and Phase II requirements the City of Indianapolis, the City of Lawrence, the City of Noblesville, the Town of Fishers, and Hamilton, Hancock, and Madison Counties are required to screen their stormwater outfalls during periods of dry weather in an effort to identify illicit stormwater discharges. According to the Fall Creek TMDL, the City of Indianapolis has learned that approximately 8% of their 145 stormwater outfalls contain wet flows during periods of dry weather. As of the writing of this plan the City of Noblesville, the Town of Fishers, and Hamilton, Hancock, and Madison Counties have not begun their dry weather screening programs as regulatory schedules have not required this action.

Wildlife and Background Levels

Wildlife within the Lower Fall Creek Watershed is a source of bacteria loadings. It is difficult to determine the exact contribution that different animals have on *E. coli* loadings; however, in many central Indiana watersheds, waterfowl have been identified as a significant source of *E. coli* loading to local waterways. Many existing commercial and residential developments within the Lower Fall Creek Watershed have ponds or lakes with unrestricted access for Canada Geese to nest and raise their young. The number of these developments with ponds can be expected to increase in areas slated for future development, such as those highlighted on Exhibit 2-2.

Habitually, ducks and geese nest in colonies located in trees and bushes around rivers, streams, and lakes. *Lake Access* is a Minnesota based initiative that began in 1999 to deliver real-time water quality information on Minneapolis metropolitan lakes to the public using advanced sensor technology and the Internet. According to their research, the average goose dropping has a dry weight of 1.2 grams and each goose is responsible for approximately 82 grams of feces per day. Common management strategies for controlling Canada Geese and other waterfowl include reducing or eliminating all mowing activities within 50' – 75' of a waterbody, minimizing watering and fertilizing activities within 50' – 75' of a waterbody, planting less palatable species of grass and plants along the water's edge, prohibiting feeding, and utilizing auditory, visual, and physical scare tactics.

Additionally, recent water quality studies done by the Maryland Department of the Environment identified pet waste as the second most common source of bacteria in the Washington DC area. Pet wastes can be controlled through ordinances requiring collection and removal of the waste from curbsides, yards, parks, roadways, and other areas where the waste can be washed directly into receiving waters.

Stormwater Runoff

Differing land uses contribute different bacteria loadings to local waterways. Causes of bacteria in stormwater runoff include domestic pet waste, wildlife, and agricultural uses. According to the TMDL, "Average stormwater *E. coli* bacteria counts were estimated from literature values and based on Indianapolis Mapping and Geographic Infrastructure System (IMAGIS) land use and watershed coverages. These bacteria counts were applied to surface runoff flows from October 1991 to October 2001 as predicted using the city's watershed model". **Table 3-10** identifies estimated stormwater *E. coli* concentrations and percentages of land use types within the City of Indianapolis as identified in the Fall Creek TMDL study.

Table 3-10: *E. coli* Concentrations and Land Use Classes in the City of Indianapolis

	Com.	Res.	Historic & Hospital	Indust.	Parks	Highways	Spec. Uses	University
Assumed *E. coli* Concentration	2,500 CFU	2,000 CFU	2,500 CFU	5,000 CFU	2,000 CFU	5,000 CFU	3,000 CFU	3,000 CFU
Mud Creek	*Assumed to be the same as Fall Creek*							
Fall Creek upstream	3%	71%	0%	2%	4%	1%	19%	0%
Fall Creek CSO	9%	65%	1%	9%	4%	2%	9%	1%

(Fall Creek TMDL, 2003)

The TMDL also discusses the anticipated *E. coli* stormwater loads to Fall Creek that come from permitted, non-permitted, and out-of-county sources. It is anticipated that 45% of the *E. coli* loads originate from permitted (storm drain outfall) sources while the remaining 55% originate from outside of Marion County. The City of Indianapolis' stormwater programs are designed to address only the portion of the loads from within Marion County.

Combined Sewer Overflows

The City of Indianapolis built its first storm sewers hundreds of years ago in order to carry stormwater away from streets and homes and into rivers. However, when indoor plumbing became available, sewage lines from homes and business were tied directly into the existing storm sewer system, which discharged directly to local receiving waters. In recognition of the water quality and health problems that this system posed, the City eventually built wastewater treatment plants to treat and eliminate sewage before it entered local waterways.

During periods of dry weather, the capacity of the sewer system and wastewater treatment plants are sufficient, and nearly all stormwater and sewage in the combined sewer system is treated by the wastewater treatment plant. However, during rain events, the capacity of the combined sewer system is insufficient, and in order to prevent sewage from backing up into basements and onto streets, combined stormwater, sanitary and raw sewage overflows into local streams.

Within the Lower Fall Creek Watershed there are 28 CSO outfalls. These outfalls are identified on Exhibit 4-3. In order to correct problems associated with CSOs the City has developed the Raw Sewage Overflow Long Term Control Plan and Water Quality Improvement Plan (LTCP). In total, the City's LTCP will ultimately capture 95-97% of sewage entering streams during wet weather and is estimated to cost the City more than $1.73B. The LTCP has detailed actions that will be taken to reduce water quality problems associated with CSOs, and should be referenced for all CSO related water quality improvements.

Among the plans identified in the LTCP to reduce sewerage overflows in the Lower Fall Creek Watershed include:

- Digging underground tunnels that will store and carry sewage to the City's wastewater treatment plant.
- Building new, larger sewers to capture overflows and carry them to the tunnel.
- Installing inflatable dams and sluice gates at key point in the sewer system.
- Separating sewers in a neighborhood near 38th St.
- Removing the dam near Dr. Martin Luther King Junior Street and Fall Creek to improve stream flow and raise dissolved oxygen concentrations. This was completed in the fall of 2007.

Livestock and Manure Management

The Fall Creek TMDL focused on bacteria sources within Marion County, and considering the limited agricultural land uses within the county, the TMDL did not discuss agricultural sources of bacteria. However, within the Lower Fall Creek Watershed, more than 22,000 acres are currently in agricultural production. Further, the Indiana State Fairgrounds' has been discussed as a potential source of manure laden runoff leading to elevated levels of *E. coli* within Lower Fall Creek.

Manure, whether being stored, applied for crop nutrition, or simply the by-product of grazing is a water quality concern in the Lower Fall Creek Watershed. The best way to manage for and mitigate the potential water quality impacts of manure application and storage is to ensure that storage, application rates, and timing aspects are appropriately addressed through the implementation of nutrient management plans on agricultural lands.

A Confined Feeding Operation (CFO) is a livestock operation that has in excess of 600 hogs, 300 cattle, or 600 sheep. These facilities are required, by IAC 16-2-5, to obtain a permit from IDEM's Office of Land Quality. According to IDEM's records, there is only 1 active CFO located in the Lower Fall Creek Watershed. In addition to this CFO within the watershed, there are Animal Feeding Operations (AFOs) in the upper reaches of the Lower Fall Creek Watershed in Hamilton, Hancock, and Madison Counties. These operations continue to decline in number and in number of cattle, pigs, and sheep at each operation. Further, Hamilton County ranks among the top 10 counties in Indiana in regard to the number of horses. **Table 3-11** identifies the total number livestock and overall state rankings for Hamilton, Hancock, Marion, and Madison County.

Table 3-11: Livestock Statistics

	Cattle		Hogs		Sheep	
	Head	**Rank**	**Head**	**Rank**	**Head**	**Rank**
Hamilton	4,300	72	10,500	62	988	23
Hancock	2,900	80	37,082	29	1,941	6
Madison	4,500	70	26,875	42	655	39
Marion	1,000	92	N/A	N/A	252	66

(NASS, 2007)

Pasture management can be an effective management measure to reduce impacts that small livestock operations have on water quality. Pasture management leads to better weed control, better soil structure, increased productivity over longer periods of time, and healthier animals. It also helps the soil absorb excess water, manure, nutrients and other pollutants and ultimately protects water quality by reducing the amount and improving the quality of runoff. As discussed earlier within Section 3.3, related to tillage practices, the Steering Committee and Working Groups have agreed that agricultural related management efforts are best led by the individual county SWCDs. Local SWCD and NRCS staff have long-established relationships with agricultural landowners as well as an extensive knowledge of USDA programs designed to mitigate livestock and manure impacts as well as those designed to protect water quality in a livestock production area.

Estimated Existing Bacteria Loads

Bacteria load reductions identified within the 2003 Fall Creek TMDL were utilized to estimate bacteria loads for the Lower Fall Creek Watershed. Based on results from the TMDL existing bacteria loads within the Lower Fall Creek Watershed are estimated at 1.59E+14 CFU/recreational season (April to October). In order to meet the water quality standard identified in Table 3.2, the TMDL calls for a 1.57E+12 CFU reduction. This equates to a 52% reduction of *E. coli* loadings upstream of the CSO area and 99.5% reduction of *E. coli* loadings downstream of the CSO area.

<u>Problem Statements</u>

After analysis of Water Quality data, evaluation of pollutant causes and sources, and estimation of existing pollutant loads the following problem statements have been developed relevant to the Lower Fall Creek Watershed.

Problem Statement #1

Macroinvertebrate and habitat assessment scores at 17 of 28 (60%) of the sites assessed scored under 60 on the CQHEI or QHEI indices. The cause for this is assumed to be due to excessive siltation observed at these sites.

Problem Statement #2

Increased levels of nutrients throughout the Lower Fall Creek watershed have harmful impacts on drinking water, recreational use waters, and aquatic plant and animal life. The cause for this is Phosphorus concentrations that routinely exceed the EPA recommended threshold of 0.076 mg/L.

Problem Statement #3

Restrictions on primary contact recreation in Lower Fall Creek have been implemented and advertised in some areas while discouraged in others. The cause for this is due to *E. coli* concentrations routinely exceeding the State of Indiana's Water Quality Standard of (geometric mean) 125 CFU/100ml.

While sediment, excess nutrients, and the potential presence of pathogens seem to be the primary water quality problems in the Lower Fall Creek Watershed, other concerns such as invasive species, diurnal fluctuations of dissolved oxygen concentrations, poor habitat quality, and impaired biotic communities have also been identified. Problem statements have not been identified for these issues as it is expected that the implementation of mitigation measures intended to reduce loadings of pathogens, nutrients, and sediments will also serve to improve habitat and biological health, and reduce invasive species.

3.4 AREA OF CONCERN SUMMARY

As a method of better understanding the cumulative impacts of the areas of concern discussed within this section, a composite map was created and is shown as **Figure 3-4**. This map can be utilized to aid in the evaluation of areas and activities of concern, the development of Critical Areas, as well as a means to direct outreach efforts related to education or implementation of BMPs designed to reduce the water quality impacts within each subwatershed. For example, many areas of concern are located within the Fall Creek – Devon Creek subwatershed. Perhaps this would be a good subwatershed to begin when starting targeted education and outreach and implementation programs.

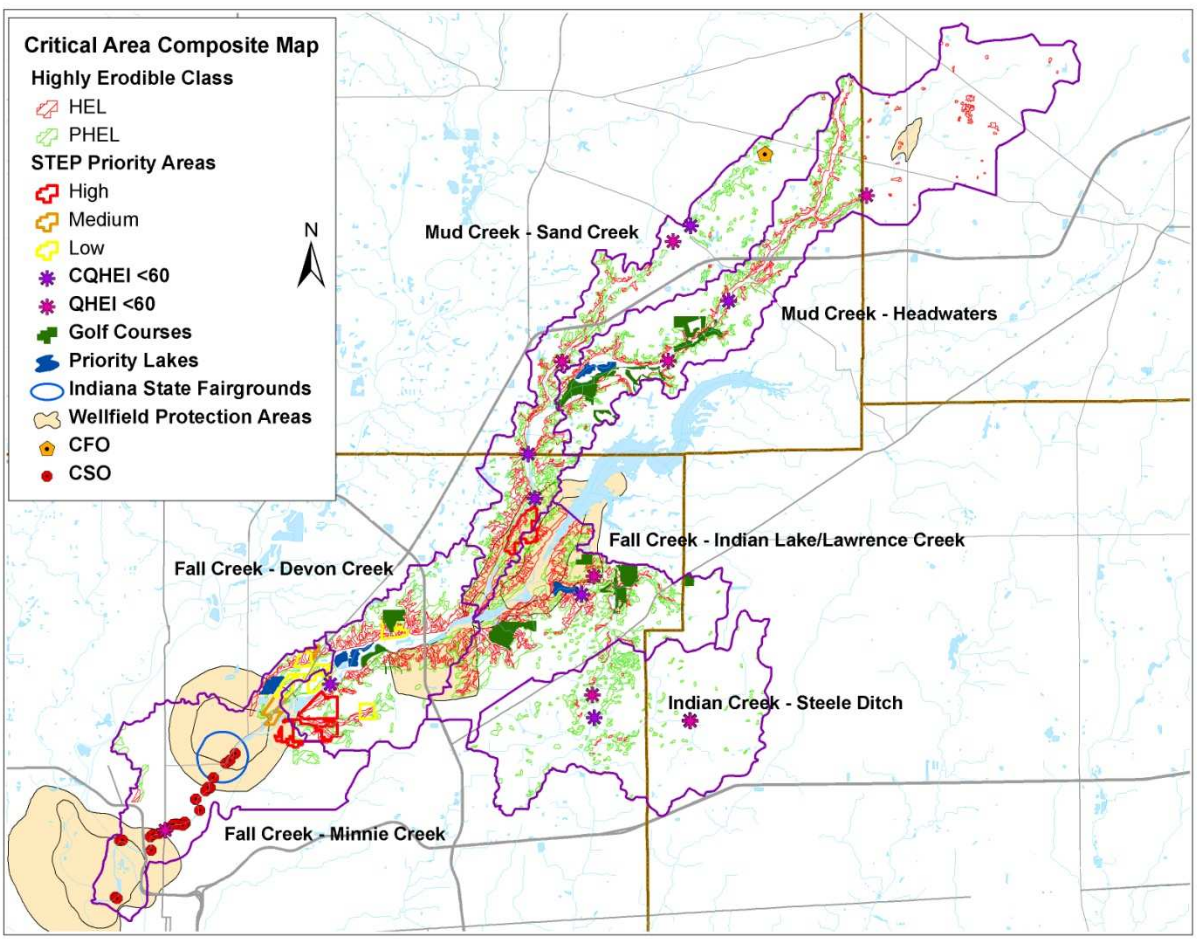

Figure 3-4: Critical Areas Composite Map

Figure 3-4 should be used in conjunction with Figure 2-2 highlighting existing land uses and areas where growth and development are expected or planned. As growth and development within the watershed is proposed, special considerations should be given to areas such as HEL or PHEL classified soils or WFPAs.